DOCUMENT RESUME

ED 091 576 CE 001 348

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TITLE	Systems Analysis in Health Manpower Education: A Bibliography.
INSTITUTION	Health Resources Administration (DHEW/PHS), Bethesda, Md. Div. of Manpower Intelligence.
REPORT NO	DHEW-HRA-74-28
PUB DATE	Nov 73
NOTE	19p.
EDRS PRICE	MF-$0.75 HC-$1.50 PLUS POSTAGE
DESCRIPTORS	*Annotated Bibliographies; Bibliographies; Health Education; *Health Occupations; *Health Personnel; Health Services; Manpower Development; *Medical Education; *Systems Analysis

ABSTRACT

The principle aim of the bibliography is to examine the reported state of the art in application of systems analysis to health manpower education through an extensive search of the literature. Admitted in this bibliography are any complete systems analyses which make conscious effort of a systems formulation of a problem in health manpower education, attacking at least one of the steps in the systems analysis process. Also included are entries concerning systems analysis related to fields outside of health, but where the approach could be used in health manpower and those related to manpower planning where the analysis has implications for numbers of people needing training at various skill levels. The first section of this document covers items in Systems Analysis in Health Manpower Education. This is subdivided into the following: general, physicians, physician's assistants, dentists, nurses, laboratory and radiology technicians, and facilities. Three additional sections covered are: Systems Analysis in Education, Systems Analysis in Health Manpower, and Abstracts. (Author/DS)

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SYSTEMS ANALYSIS IN HEALTH MANPOWER: A Bibliography

SYSTEMS ANALYSIS IN HEALTH MANPOWER EDUCATION

A Bibliography

DHEW PUBLICATION NO. (HRA) 74-28

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE – HEALTH RESOURCES ADMINISTRATION
Bureau of Health Resources Development
Division of Manpower Intelligence

November 1973

FOREWORD

This report is a preliminary effort toward developing a bibliography on systems analysis in health manpower education. It was prepared by Dr. Charles D. Flagle of Johns Hopkins University at the request of the Division of Manpower Intelligence. Comments and suggestions on additional items that might be included in a later bibliography will be welcome.

W A Lybrand

William A. Lybrand, Ph.D.
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SYSTEMS ANALYSIS IN HEALTH MANPOWER EDUCATION

A Bibliography

Preface

There is a large and growing literature devoted to the education of manpower for the health services. Developments in the delivery of health services are reflected in the changing roles of existing professions and in the evolution of new personnel categories. These in turn impinge on the substance of teaching and on the philosophy and organization of educational programs.

Some of the analytic writing in the area reveals an effort to base decisions about health manpower education on recognition of education as an element or subsystem in the total system of health services. Where consideration is given to the goals of education and to the search among alternatives for the best allocation of resources to meet those goals, the effort may be classed as systems analysis.

On review, it must be concluded that there is not, at present, a systematic body of literature in the area. Few of the papers uncovered in our search make reference to others. None report a full scale systems analysis. Nevertheless, systems concepts have inspired enough activity to justify collecting a group of papers into a bibliography.

There is a sequence of steps in the formal process of systems analysis: (1) the recognition of a system and its objectives, (2) the identification of controllable and uncontrollable variables and their effect on outcomes, (3) the synthesis and evaluation of alternative strategies for use of resources to achieve objectives, (4) the selection of an optimal strategy in terms of benefits and costs. The process is accompanied characteristically by attempts at quantitative expression of outcomes in terms of measures of effectiveness and by the development of a model to portray the relationship between these measures of effectiveness and the variables under control of a decision maker.

The principal aim of the bibliography is to examine the reported state of the art in application of systems analysis to health manpower education through an extensive search of the literature. Anticipating that there would be few, if any, complete systems analyses, covering all the steps of the process, we have admitted those papers which make a conscious effort at a systems formulation of a problem in health manpower education and attack at least one of the steps in the systems analysis process. About 30 papers meeting this definition have been found. These divide into categories; first the set of general studies covering any type of personnel and several aspects of organization; second, those sets that deal with specific personnel groups.

A number of the papers are abstracted in Section D of the bibliography, chosen on the basis of their illustration of some aspects of systems analysis methodology. Together the abstracts illustrate the range of interpretation of the term systems analysis and the pioneer efforts to make useful application of it.

Confining the bibliography to entries dealing directly with health manpower education would eliminate a number of references of use for future analysis. Therefore, the specifications have been broadened to include selected systems analysis of two other kinds: (1) those related to manpower training in fields other than health, where the approach might be carried over to health manpower, and (2) those related to manpower planning, where the analysis has implications for numbers of people needed to be trained at various skill levels.

A wide range of sources has been searched for all work bearing on systems analysis in manpower education: Index Medicus, ERIC, International Abstracts in Operations Research, the Science Information Exchange, and Hospital Abstracts prepared by the Ministry of Health in Great Britain. The journals of the fields of health, education, operations research, and management science have been a useful source of material.

In addition to formal searches, conducted by Joan Peterson, Research Assistant, many suggestions for inclusion in the bibliography have come from colleagues working in the field of health manpower. We are indebted to John Stringer of the Institute for Operational Research, London, for several contributions; also to Miss B. W. C. Sammis, Librarian of the Ministry of Health and Social Security in England, who made available the facilities of the Ministry's Library and the excellent material contained in Hospital Abstracts; and to Elizabeth Martinsen and Wanda Tesar, Librarians of the Bureau of Health Manpower Education and the Johns Hopkins School of Hygiene and Public Health, respectively, who made helpful suggestions for the bibliography.

Considering the diversity of sources of material, it is unlikely that all papers worthy of inclusion have been found. It is hoped that the bibliography will be revised and brought up to date in due time.

May, 1973

Charles D. Flagle

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D. ABSTRACTS

Alper, P., Armitage, P.H., and Smith, C.S. Educational models, manpower, planning, and control. *Operational Research* Quarterly, 18:93-103, June 1967.

The educational system is described in terms of its structural elements by two basic equations that relate the number of teachers and students at some level of the

* Papers marked on the right are abstracted and included in alphabetical order in Section D.

training process to rates of transition into that level by transition from outside or from other levels. In this way projections can be made of future states of the systems, i.e., numbers of students and teachers at each level, given knowledge of present states and the factors that influence transition. Such a model is to "be regarded simply as a tool which permits some estimation of the outcomes of possible future courses of action." Two basic approaches are considered: first the estimate of future manpower needs, with parameters adjusted to control admissions and transitions along a trajectory to meet needs; second a projection of numbers of educated persons emerging from specific sets of training resources. The latter approach recognizes that training to meet manpower needs is not the only goal of the educational system. The need to state targets and to define an objective function which embodies preferences with respect to possible conflicts among targets is discussed.

Caldwell, M.S. An approach to the assessment of educational planning. *Educational Technology*, 8:5-12, 15 Oct. 1968.

A procedure is developed for evaluating the planning of change in educational settings. The purpose is first to provide a framework within which the concept of plans assessment might be viewed, and then to suggest a systematic approach, including an illustrative set of evaluative criteria, for implementing a plans assessment. The author builds on the notion that improvement or change proceeds through the following phases: (1) identification and priority ranking of needs, (2) development of broad strategies and specific plans for meeting selected needs, (3) implementation of the selected approaches, and (4) assessment of outcomes. This broad scheme does not recognize explicitly the difficult step, internal to the development of strategies and plans (phase 2), of choosing from among alternatives the plan to be implemented. To fill this gap, the author proposes a Program Selection Process in which major decision points are recognized: first to select a strategy from available alternatives, second to select a preliminary plan based upon that strategy, then to accept or reject a fully explicated form of the plan. Each decision is proceded by a step of plans assessment, testing the plan for such criteria as relevance, legality, congruence, legitimacy, compatibility, balance, practicality, and cost/effectiveness.

Farmer, P.J., Shipp, P.J., and Wiseman, H.C. *The recruitment, length of training and success rates of student radiographers in Scotland.* London, Institute for Operational Research, 1970. 8p. (IOR/526)

The purpose of the study is to assess adequacy of the number of trained radiographers in Scotland. The method used is cohort analysis, which follows the progress of a group of students entering training. Factors affecting the supply of newly qualified radiographers are the rate of intake of new students, the wastage (dropout) rates and duration of training for successful completion. In actual numbers, radiographers in Scotland incrased from 475 to 575 whole time equivalents between 1962 and 1969. Wastage rates are 8-10%, and 39% of the students require more than 2 1/2 years to complete the 2-year program successfully.

Francis, N.D. *Control concepts in educational planning.* Dublin, Department of Computer Science, Graduate School of Engineering, Trinity College, 1971. 30p.

The author proposes the usefulness of a model of system dynamics for planning administration of educational systems. The student flow, teachers, and equipment are the input variables and the outputs are expressed as the inventory of personnel with various qualifications, and as losses to the inventory through death and emigration. The model used is a closed loop control system with some decision point for controlling flow of inputs. Concepts of observability, controllability, and stability are introduced. Mathematically, the model is represented as a vector matrix differential equation. What is controllable at any point in time is the rate of inputs, e.g., new students or teachers per year.

The model and approach are admittedly tentative, for the presence of human beings in the system may intervene in some as yet undefined way to alter system behavior from that predicted by models developed around physical or mechanical systems. The models proposed are conceptual and mathematical, and it is assumed their complexity would increase with attempted application to educational systems.

Gravenstein, J.S. and others. *Analysis and forecasting of anesthesia manpower in Cuyahoga County, Ohio.* Cleveland, Operations Research Department, Case-Western Reserve University, 1972. 144p. (Technical Memorandum No. 259)

The purpose of the study is to develop a ten-year plan for recruitment and training of anesthesia manpower.

On the basis of task analyses of the anesthesia function in hospitals and forecasts of need for anaesthesia manpower in Cuyahoga County, Ohio, an approach to recruitment and training has been developed.

Analysis of pre-, intra-, and post-operative tasks yields division of personnel into three categories:

1. A low category (sic), requiring little education, performing essential supportive tasks.
2. An intermediate category at college level in biological sciences, physiology, pharmacology, and enough engineering to handle any emergency repairs of equipment.
3. The highest category requiring a physician trained in anesthesiology.

To fill the need for Cagetory 2, an undergraduate curriculum was developed and offered in Spring 1971.

A survey of the present volume of surgery, anesthesia procedures, and anesthesia manpower resources in Cuyahoga County was made. Forecasts of the volume of anesthesia to 1980 were made by multiplication of age/sex specific surgery rates by age/sex population groupings projected to 1980.

Grinker, R.R. Biomedical education as a system. *Archives of General Psychiatry,* 24:291-97, Apr. 1971.

The author takes a system-theoretic view of biomedical education, arguing that there exists a core area of knowledge basic for all biomedical students independent of specialty or career goals. This is a knowledge of the health-illness system, the process of life over a continuity of time, the phases of development and regression,

progressing from infancy through childhood, adolescence, and adulthood to the stage of aging with illness characteristic of the wearing process. The system of education proposed is a multidisciplinary experience appropriate to each phase of the life cycle. The concept draws on the notions of a general systems theory which sees physical nature characterized by randomness and disorder, while living systems create order in the direction of their goals and norms through sensing, communication, and feedback mechanisms.

Health Sciences Functional Planning Unit. *The clinical training model.* Toronto, University of Toronto, 1969, 74p.

The Health Sciences Functional Planning Unit has developed a mathematical model, given the acronym TRANEE, a computer based simulation of the interaction of faculty, patients, and students in the training of clinical specialists and other health professionals. Variables treated are:(1) the number of students to be trained, (2) the number of patients available for teaching purposes, (3) available faculty time, and (4) the educational experiences to be provided in the program. In the model one variable can be treated as dependent with the other three treated as independent for a particular analysis, e.g., given specification of necessary clinical experiences and available faculty time, the number of students trainable can be estimated. Precise rules and forms for gathering input data are given. Outputs from the model may be program resource requirements or specification of program content. An illustrative evaluation of use of the model is given for the gynecology program, in which the effects of changing various constraints, e.g., increasing the number of clinical clerks, is given. The TRANEE model demonstrates the capability of simulation to permit the planner to test the influence of variables under control and to demonstrate the sensitivity of outcomes to constraints.

Judy, R.W., and Levine, J.B. *A new tool for educational administrators; educational efficiency through simulation analysis.* Toronto, University of Toronto Press, 1965. 33p.

The high cost of higher education, and its great benefits, force careful consideration of the task of resource management. The formulation of an objective function for a university, expressing level of achievement in activities is related to an education function which expresses the relationship between activity levels and resource requirements. By means of a system simulation model, which includes the interaction of activity levels, uncontrollable variables, system parameters and resource requirements, it is possible to make estimates of resource requirements for specific sets of activity levels, or to identify possible activity levels within the constraints of limited resources. The time estimated to construct a university simulation is about two man-years for an experienced model building team.

Moores, Brian. *The allocation of student nurses to match patient requirements in different hospitals on the assumption that a shortage of staff leads to increased wastage.* Baltimore, The Johns Hopkins University, 1971. 310p. (Thesis - Johns Hopkins University)

The problem of "wastage" or dropout of students from nursing training programs is recognized as a serious one in hospitals in Great Britain. On the

hypothesis that wastage is exacerbated by excessive nursing workloads, an algorithm is developed for distributing student nurses in clinical training among hospitals, so as to minimize the costs associated with wastage. Data are gathered on labor turnover and workloads in a sample of hospitals. Data on current hospital operations do not support the hypothesis that current workloads are positively correlated with turnover. Application of the assignment algorithm is not justified under present circumstances; however, the data on turnover is useful in planning recruitment rates for training programs.

National Institutes of Health. Bureau of Health Manpower Education. Office of Program Planning and Evaluation. *The use of analytical techniques in the management of programs of health manpower education.* Bethesda, Md., 1971. 70p.

The purpose of this internal document of the Bureau of Health Manpower Education is to explore the applicability of several quantitative, analytical techniques to the problems of health manpower education. Four categories of analytic process are recognized: Systems Analysis, which is interpreted as the study of decision processes, e.g., objectives, alternative strategies, estimated outcomes; Economic Analysis, which is interpreted as the study of financial factors, e.g., cost, price, expenditures; Statistical Analysis, which is interpreted as the study of data, e.g., supply of manpower, trends, requirements; and Logical Analysis, which is interpreted as the study of concepts and symbols, e.g., terms, definitions, meaning, inference, validity.

Examples of each of these approaches in activities related to health manpower are given. Recommendations are made to expand analytic capabilities in program management to improve decision making and, whenever feasible, to formulate major program-management problems in a systems analysis mode.

Shipp, P.J. *Manpower planning in the Scottish National Health Service.* London, Tavistock Institute of Human Relations, 1971. 33p. (IOR Health Report No.5)

Concern for adequate health manpower prompted a set of seminars in 1969. Participants in the seminars concluded that a Manpower Planning Unit should be established to advise the Scottish Home and Health Department. The approach is to define a Manpower Process as those activities that relate to manpower recruitment, training and control. A model is developed for a proposed manpower planning system. The model begins with the population and its environment, present and future, producing health needs. Manpower requirements are assessed and compared with projected manpower production. A gap between need and supply signals a need for change in training rates or recruitment policy. It is emphasized that manpower planning is integral to health service planning.

Methodology is presented for forecasting future manpower needs, staff learning rates and recruitment and training rates. The planning model is applied to nurse staffing in Dumfries, an exercise which reveals a need to increase recruitment by increased training or drawing from outside.

Stanford University School of Medicine. Medical Facilities Planning Group. *Clinical: teaching and health care systems: models and evaluation: a report to the Commonwealth Fund.* Stanford, Calif., 1969. 284p.

The Medical Facilities Planning Group has undertaken a study toward design of a hospital and ambulatory care center for Stanford University. Systems analysis is proposed as the approach because of the complexity of health systems and the costliness of experimentation. Central to the approach is the creation of a model of the system, one that represents it as a composite of subsystems whose performance and interactions can be described.

In the first chapter, co-author, G.R. Murray, Director of the Group, develops a clinical teaching model which recognizes the fundamental characteristics of training taking place within the context of patient care service. The model describes a teaching program as a set of required sub-programs, the number of students entering each sub-program, and the clinical activities. Clinical activities are defined in terms of resources required for clinic function and teaching-service team composition. Within the constraints of program requirements and team composition, various configurations of clincial experience can be evaluated for such resource requirements as faculty hours, new patient experiences, clinic hours. Comparisons are made of facilities and personnel requirements for several mixes of outpatient and inpatient clinical experience.

Other chapters deal with operating procedures in nursing units and ancillary services. There are several general models of health care systems, without specific reference to manpower education.

Tomlinson, R.M. Conceptual model for considering utilization and education of medical laboratory personnel. *American Journal of Medical Technology*, 36:67-74, Feb. 1970.

The problem discussed is the transition of the medical laboratory field from one of stability in structure to one of growth in size and in the number of levels and specialties of practitioners. Such periods of transition produce uneasiness among participants as their ultimate role is sought in the new organization form. The approach is by construction of a model relating the inputs or components of the system to those outputs which reflect the goals of the system. The model is based on the *Taxonomy of Educational Objectives: Cognitive Domain*, of Bloom et al., which progresses from (1) knowledge through (2) comprehension, (3) application, (4) analysis, (5) synthesis to (6) evaluation. A taxonomy of functions in the medical laboratory is constructed, ranging from laboratory procedures to diagnosis. The capabilities or educational levels required for these functions are set forth and corresponding sets of personnel levels are defined, ranging from laboratory aide to pathologist. The purpose of the model is to define preparations required for each personnel level and to identify additional competencies required for the next higher level.

Wilson, Richard, Wolfson, W., Centner, S., and Walter, J.R. Systems analysis in health sciences educational planning. *Canadian Medical Association Journal*, 100:715-23, 19 Apr. 1969.

Systems analysis is defined as a specific approach to decision making, carried out in four steps: (1) ascertaining and understanding objectives (2) determining constraints, (3) generating and elaborating alternatives and (4) estimating costs, benefits, and risks of feasible alternatives. Step 3 requires exploration of the relationships between resource inputs and measures of outputs which reflect objectives of the systems. To implement this process a computer based simulation model has been developed to examine the resource implications of alternative educational programs. In a simulation of undergraduate medical education, student contact hours with teachers and with patients are determined for several forms or organization. The major comparison is between a traditional departmental curriculum and a new systems curriculum. Increases in contact hours are demonstrated for the latter. The number of exposure hours of patients and the number of teaching beds are also calculated.

The requirements for successful systems analysis include receptivity of decision-making to formal analysis, a willingness to explore objectives and provide access to data, and an understanding that systems analysis does not make decisions but makes decisions easier to make.

Wing, Paul. *Planning and decision making for medical education: an analysis of costs and benefits.* Berkeley, Ford Foundation Program for Research in University Administration, University of California, 1972. 188p. (Paper P-28)

The paper approaches the problem of allocating resources to and among programs at public medical schools. A premise underlying the decision process is that change in emphasis in medical education can occur only slowly. A distinction is made between political decision making, where no agreements exist about objectives, and economic decision making, where market forces diminish political influence. Several forms of economic analysis are discussed as a basis for planning and decision-making in medical education: systems analysis and cost benefits. The distinction is made that the former requires knowledge of the internal function of the system.

Estimates are made of operating costs, cost trends and capital costs of medical education. A detailed analysis is made of floor space utilization in terms of numbers of students, faculty and interns, and type of school. Estimates of total direct cost per student per year are in the neighborhood of $4,600, of which slightly less than 60% is borne by federal and state governments. The efforts and difficulties of measuring public benefits of medical education are reviewed. The state of measurement of health benefits does not permit a cost benefit analysis of medical education, nor does it permit a conclusion favoring increased physician training under public support. The paper reveals the need for more research on the determinants of health and the development of sensitive health indices. In the meantime, since medical education will continue, studies should continue of the process of medical education and its support.

Wolfe, Harvey. *Optimal length of training for a female nursing aide*. Baltimore, The Johns Hopkins University, 1962. 100p. (Thesis (M.S.) Johns Hopkins University)

Labor turnover is a significant factor in the design of training programs for nurses' aides for acute hospitals. The turnover rates experienced, in the neighborhood of 100% per year, mitigate against long training programs. Programs too brief do not equip the trainee to make a worthwhile contribution to patient care. A model of the training program yields estimates of optimal duration of training as a function of prevailing turnover rates under circumstances existing all the time of the study. In-service training programs of five weeks duration appear optimal.

Yett, D.E., Drabek, L., Intriligator, M.D., and Kimbell, L.J. Health manpower planning: an econometric approach. *Health Services Research*, 7:134-47, Summer 1972.

The demand for health manpower training is described in an economic model in which two markets are recognized. The human population creates, through illness and accident, a demand for service from providers, creating a service market. The service resources thus developed create in turn a labor market for trained personnel. Once again, maintenance of the pool of trained personnel create a demand on the population for trainees and a training market.

Demand for health services is expressed as a function of size and demographic characteristics of the population and financial variables including cost of care and ability to pay.

Yett, D.E., Drabek, Leonard, Kimbell, Larry, and Intriligator, Michael. The development of a micro-simulation model of health manpower supply and demand. In: Conference on a Health Manpower Simulation Model. *Proceedings and Report*. v. 1. Washington, National Institutes of Health, Bureau of Health Manpower Education, Division of Manpower Intelligence, 1970, p. 9-208.

A simulation model has been constructed to represent the behavior of the major elements within a health service system of national scope with emphasis on the demand for and supply of health manpower. In structure there are three modules, one for health services, one for health manpower, one for health education. In the first module, the population of individuals in need interacts with the population of health institutions to create the health services market and a demand for health manpower. The existence of a population of health manpower, the second module, creates a market for health manpower and a demand for health graduates. In the third module, the populations of health education institutions and students create a market for health education and a supply of graduates. The analog in the simulation is a set of equations describing interrelationships of entities, attributes, and events among the elements of the system. The model exists in two forms, one beyond present data resources, another within data resources and computational capabilities. The model affords the capability to assess the effects of societal change affecting demand for health services on the market for health manpower and ultimately on the volume of training.